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WOODS HOLE OCEANOGRAPHIC INSTITUTION

Woods Hole, Massachusetts 02543

Phone: (508) 289-2227

FAX (508) 457-2187

Telex 951679

Department of Geology & Geophysics

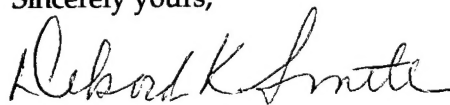
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Defense Technical Information Center
8725 John J. Kingman Road
STE 0944
Ft. Belvoir, VA 22060-6218

Dear Sir:

In compliance with the reporting requirements of ONR Grant No. N00014-94-1-0319 entitled "The Off-Axis Volcanic Record in the ONR Atlantic Natural Laboratory", P.I.s Deborah K. Smith and Brian E. Tucholke, enclosed are two copies for your files.

Sincerely yours,


Deborah K. Smith

DKS:pf

Enclosure

The Off-Axis Volcanic Record in the ONR Atlantic Natural Laboratory

Final Report for Grant No. N00014-94-1-0319

Deborah K. Smith and B. E. Tucholke
Department of Geology and Geophysics
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
email: dsmith@whoi.edu; btucholke@whoi.edu
office: (508) 289-2472; 289-2494
fax: (508) 457-2187

Long Term Scientific Objectives and Goals

Our long range scientific objective is to understand the operation and distribution of processes that control construction and degradation of volcanic edifices on the seafloor. Submarine volcanoes (seamounts) significantly contribute to or even dominate roughness characteristics of the seafloor in many parts of the world's oceans. Despite this fact their fundamental distributions and the controls on their distributions remain poorly understood. To begin to address this problem, our short term objective was to understand the distribution of seamounts in the ONR Natural Laboratory located on the western flank of the slow-spreading Mid-Atlantic Ridge (MAR), and to interpret the responsible processes. Our long term goal is a quantitative model for the production and degradation of seamounts as a function of tectonic setting, spreading rate, crustal age, and volcano size.

Background

On the inner floor of the median valley of the slow-spreading MAR, volcanic edifices rather than faults dominate the topography. Surprisingly little is known, however, about how seamounts generated at the ridge axis are degraded as the crust is faulted during uplift into the crestal mountains. Even less is known about abundances, size distributions, and spatial locations of seamount remnants. Furthermore, while it is well known that abundant volcanoes are constructed off-axis in the Pacific, there is no comparable understanding about off-axis construction in the slowly spreading crust of the Atlantic. The primary focus of this investigation is to understand the long temporal record (~28 m.y.) of volcanism in the ONR Atlantic Natural Laboratory.

Approach

To accomplish our scientific objective, our approach was to identify and compile statistics on the sizes, shapes and locations of seamounts on the MAR and its flank using the large multi-sonar data set collected during the 1992 and 1993 ARSRP geological and geophysical cruises. The region is ~75,000 km² in area, and is located along the western flank of the MAR between about 25.5-27°N, extending out to ~28 m.y. crust. Seamounts were identified visually from Hydrosweep multibeam bathymetry and HMR1 sidescan sonar data as near-circular features with heights, $h \geq 60$ m. We developed a simple program that runs interactively in the MATLAB environment to obtain from the digital data each seamount's basic physical parameters (e.g., height, basal diameter, summit diameter), its shape characteristics (e.g., ellipticity), and its location (latitude

and longitude). This information was stored automatically in a digital data base which we used to investigate the patterns of seamount production.

Accomplishments and Results

In contrast to previous North Atlantic studies, our results show that the Natural Laboratory contains abundant seamounts. Our work suggests that seamounts observed off-axis in this region were constructed on the median valley floor of the adjacent MAR and then transported to the ridge flanks. We base this primarily on two observations. First, we see *no* evidence that seamounts are formed off-axis: i.e., 1) no unusually high reflectivity in HMR1 sidescan sonar images, and 2) no construction of volcanoes across faults. Second, the abundances and sizes of seamounts in our study region are similar to those observed on the inner valley floor between the Kane and Atlantis transforms. If this observation holds up, then sections of new oceanic crust commonly several kilometers wide must be carried intact up the faulted valley walls and to the rift mountains and Mid-Atlantic Ridge flank.

A total of 1376 seamounts in the height range 60-560 m were identified within the Natural Laboratory. Eighty six seamounts were recognized within the axial zone (0-0.6 m.y. crust). In the off-axis region (0.6-28 m.y. crust), 1290 seamounts were identified. Seamount population parameters were estimated from the seamount height distributions for various subsets of the data defined by variables such as crustal age and spatial location. We estimate an average seamount density of 76 ± 8 seamounts per 10^3 km^2 from the axial population, and a lower average density of 58 ± 2 per 10^3 km^2 from the off-axis population. Furthermore, the axial population has an estimated characteristic height of 92 ± 4 m, while the off-axis population has a much smaller characteristic height of 51 ± 1 m.

We investigated the variation in the population parameters as a function of crustal age. Immediately off-axis (> 0.6 m.y.) in the rift mountains we document a significant decrease in the characteristic height of the seamount population. We attribute this to a combination of faulting and backtilting during transport out of the axial valley. There is a steady decrease in characteristic height with crustal age on the ridge flank which may be related to processes such as mass wasting, that degrade the volcanic edifices over time. In contrast to the characteristic height, we document that the average number of seamounts of all sizes does not change immediately off-axis, but instead is constant until ~ 2 -3 m.y. This suggests that within the first 2 m.y. as the crust spreads away from the axis the seamount shapes are being altered, but the seamounts are not being destroyed. In the rift mountains, however, seamount abundance decreases significantly from that on the axis, most likely due to the destruction of seamounts by additional faulting on new or pre-existing faults. Further variations in seamount densities as a function of crustal age appear to reflect sedimentation and possibly temporal variations in axial seamount production.

We also related seamount population parameters to variables such as their location within a spreading segment. Comparing segment centers to segment ends, we found no significant differences in the characteristic heights of the seamount populations, nor the average seamount densities. Similarly when sorted by tectonic setting (inside corner crust, outside corner crust, and segment center) we did not document any differences in the population parameters. These results suggest that (a) the magma delivery system in the shallow crust does not reflect crustal variations related to 3-D magmatic upwelling at segment centers, and/or (b) variations in along-axis

seamount production do exist but are not reflected in the seamount statistics. In this latter case the style of volcanism may change along the axis such that low-relief flows rather than edifices are produced more commonly, or seamounts bury each other and therefore, true abundances are not obtained.

Impact on Science

Because of the unique, large areal extent of our data sets, this study is the first to provide strong constraints on possible models of magma supply in slowly spreading ocean crust, and it has allowed us to investigate linkages between volcanic surface features and specific mechanisms of magma emplacement.

Relationship to Other Projects

Our study was integrated with several others which are investigating crustal structure, material properties, and evolution in the ONR natural laboratory (e.g., Jaroslow and Tucholke, Tucholke and Stewart; Tivey). The improved understanding of seamount distributions, morphology, and backscatter characteristics that this study provides will directly benefit the ONR Acoustic Reverberation Special Research Program which is investigating the mechanisms and seafloor features responsible for bottom/subbottom acoustic reverberation in this region.